local bench of magistrates for many years. He will be remembered in Brighton for his active and philanthropic life and his many and munificent charities. He was a liberal supporter of the Sussex County Hospital, and had attended a meeting of its Board on the morning of the day he died. He was elected a Fellow of the Society on January 11, 1867.

THOMAS REYNOLDS WHITE died at his residence, Killingworth House, Northumberland, on May 29, 1883, after a long illness, caused by paralysis, aged 70 years. He was descended on his mother's side from an ancient Northumbrian family (the Killingworths of Killingworth), and inherited with other relatives a portion of the old lands. He possessed a taste for scientific pursuits, but had little time at his disposal to devote to them, being for many years fully engaged in business in London, as a manufacturing chemist, at Castle Street, Saffron Hill, until illness compelled him to discontinue his active interest in it. He served as one of the Local Commissioners for Finsbury for the Exhibition of 1851. He had been a member of the old Mathematical Society from his youth, on the introduction of his father, who had also been a member from early years; and he became a Fellow of this Royal Astronomical Society, with the other members of the Mathematical Society, in 1845.

ANTOINE FRANÇOIS JOSEPH YVON VILLARCEAU was born at Vendôme, Loir-et-Cher, on January 15, 1813. After having completed his education, so far as was attainable in the college of his native town, he proceeded to Paris, soon after the Revolution of 1830, full of enthusiasm for literature, art, and music. Here he continued his studies at the Conservatoire with so much success that before leaving in 1833 he obtained a first prize. Having adopted with great fervour the peculiar doctrines of Saint-Simon, he, in the same year that he quitted the Conservatoire, accompanied Félicien David to Egypt as a member of a mission of that sect, at that time stationed there under the direction of M. Enfantin. From his association with the engineer officers of that mission, especially with his friend Lambert Bey, he first obtained a taste for those branches of mathematical and mechanical science in which he afterwards became so distinguished. Returning to Paris in 1837, he became a successful student at the École Centrale, where he remained three years.

Possessed of independent means sufficient to remove all necessity for seeking immediate employment, M. Villarceau, after completing his education at the Ecole Centrale, devoted nearly all his time to the study of analysis and geometry, so that he might have readily at hand the means of investigating the higher questions in mechanics and astronomy. As the first result of this continuous study, he, in 1845, presented a memoir to the Académie des Sciences, entitled, "Méthode de correction des éléments approchés des orbites des comètes au moyen de trois

observations," an abstract of which is inserted in the *Comptes Rendus*, vol. xx., and afterwards more fully in the *Receuil des Savants Etrangers*. This paper was received favourably by astronomers, and especially by Arago, who, struck with its originality, offered M. Villarceau the post of aide-astronome, as he had previously done to other young rising astronomers who had similarly distinguished themselves. In 1846 M. Villarceau became, therefore, a member of the staff of the Paris Observatory, to which he remained attached to the end of his life. In 1854, soon after the appointment of M. Le Verrier to the directorship of the Observatory, he was promoted to the higher and more permanent rank of astronome-titulaire, which, though not interrupting his usual duties, was the means of giving him greater facilities for continuing his mathematical researches in astronomy, geodesy, and mechanics. At this time, and for several years afterwards, he was accustomed to take a share in the ordinary daily observations, especially with the transit instrument of Gambey. He also made some observations of comets with the Equatorial, including those of Brorsen, Tempel (1859) and others.

Among the first of M. Villarceau's theoretical memoirs which attracted attention out of France were those relating to his researches on the relative orbits of double stars. Fully recognising the important labours of Savary, Encke, and Sir John Herschel on this subject, he attacked the problem with great vigour, taking advantage of the accumulated materials of former observers to calculate accurately, as examples, the orbits of several important binary systems. The first memoir connected with these researches was presented to the Académie des Sciences early in the year 1849; and it gives a mathematical explanation of the method adopted by M. Villarceau in the calculation of the orbits of several double stars, notes on which were communicated to the Academy at various times during the same year. In obtaining materials for these investigations he was greatly assisted by the MM. Struve, who liberally supplied him with several series of unpublished observations, which enabled him to calculate, by his method, the elements of the orbits of ζ *Herculis*, η *Coronæ*, and ξ *Ursæ Majoris* with great confidence. These valuable memoirs and notes are contained in the Appendix to the *Connaissance des Temps* for 1852. This Appendix also contains an elaborate paper on a "Méthode pour calculer les éléments des Planètes, ou, plus généralement, des Astres dont les orbites sont peu inclinées à l'ecliptique, fondée sur l'emploi des dérivées relatives au temps, des trois premiers ordres de la longitude géocentrique, et du premier ordre de la latitude." A more extended memoir, "Détermination des orbites des Planètes et des Comètes," is given in Vol. III. of the *Annales de l'Observatoire de Paris*. The principle of the method adopted in this investigation "is the same as that used by Laplace in his solution of the same problem; but M. Villarceau has pointed out, and skilfully discussed, the various circumstances which render a modification of

the form of solution indispensable, and has given convenient formulæ applicable to each particular case. He has also shown how the elements may be rectified, by a process of approximation founded on applying successive corrections to the coefficients of the expressions for the geocentric longitude and latitude, the values of these corrections being obtained by the solution of a system of linear equations." (*Monthly Notices*, vol. xix. p. 42.)

M. Villarceau was not slow to apply his revised method in the calculation of the elements of the orbits of several of the minor planets and comets. Elements and ephemerides of the planets *Amphitrite*, *Hebe*, *Iris*, and *Victoria* were computed with great care, and distributed among astronomers, by whom they were found to be of great value for the comparison of the tabular places with the observations of those planets. In calculating his normal positions, M. Villarceau was careful to use as many observations as he could possibly obtain, as may be gathered from the following extract from one of his notes on the planet *Victoria*. He remarks:—"To obtain still greater accuracy, I have represented graphically the comparisons published by MM. Hartnup, Carrington, Vogel, and Graham, along with those of the Observatories of Paris and Cambridge. I have also deduced comparisons from three months' observations made at Washington and collected by Mr. Ferguson. In this way I have constructed nearly 200 ordinates in Right Ascension and as many in Declination, representing the excess of observation above the computations of the ephemeris." Altogether, M. Villarceau has computed about twenty series of elements and ephemerides of the minor planets and comets. He was the first to determine the periodicity of the comet discovered by D'Arrest on June 27, 1851; and it was by the aid of an approximate ephemeris communicated by him to Mr. Maclear that this comet was detected at the Cape Observatory in December 1857, on its first predicted return to perihelion. In July 1861 M. Villarceau presented to the Academy a second series of investigations on the orbit of D'Arrest's Comet. Of other comets whose orbits have been calculated by him, the details of which are given in the *Comptes Rendus*, we need only name those of Petersen, Comet V. 1857, and the great Comet of 1858 (Donati).

In the *Comptes Rendus* for 1872, M. Villarceau has a memoir, entitled, "Sur la Constante de l'Aberration et la Vitesse de la Lumière considerée dans leurs rapports avec le mouvement absolu de translation du système solaire," in which he introduces into the theory of aberration the proper motion of the solar system, and points out that four determinations of the coefficient of aberration relative to four stars, not all situated on the same circle of the sphere, are sufficient theoretically to determine the three coordinates of the motion of the solar system, and practically to fix within the maximum limit the velocity of the Sun in space.

The Catalogue of Scientific Papers of the Royal Society,

to 1873, gives the titles of seventy-three separate papers of M. Villarceau. He is the author, however, of many more—probably more than a hundred in all; but they are by no means confined to astronomical subjects. In his mechanical papers he gives abundant evidence of his high mathematical power, in illustration of which we need only refer to his memoirs on "Arches de Pont"; "On the Theory of the Stability of Locomotives in Motion"; "On the Analytical Theory of Foucault's Gyroscope"; and to his researches on the rates and compensation of chronometers. In this last memoir (Vol. VII. of the *Annales de l'Observatoire*) he apparently shows that it is not difficult to determine by trial the six coefficients of the expression which represents the rate of a chronometer more or less compensated. His method for correcting chronometers for errors of compensation, described in this memoir, has been confirmed by Commandant De Magnac, after twelve years' comparison at sea, the details of which are given in "Traité de nouvelle Navigation astronomique."

One of the most important works undertaken by M. Le Verrier during his superintendence of the Paris Observatory, was the galvanic determination of the difference of longitude between Paris and important stations in France and neighbouring countries. That distinguished astronomer had not been in office many months when, in conjunction with the Astronomer Royal, he commenced this series of longitude operations, by determining the difference of longitude between the Observatories of Paris and Greenwich. Though M. Villarceau had very little to do with this first determination, it appears that the discussion and preparation of many of those which followed were intrusted to him, as may be seen on reference to Vol. VIII. of the *Annales*. In this volume are given full details of the operations carried on in the years 1861 to 1865, connected with the astronomical determinations of the longitudes, latitudes, and azimuths of Dunkirk, Brest, Biarritz, Madrid, Strassburg, Nantes, Talmay, &c. In each of these memoirs M. Villarceau has arranged the details in a very systematic manner, so that no difficulty is found in following the course of the whole operation from the beginning to the end. In performing this work, for which he was so well fitted, he had evidently relieved M. Le Verrier of much labour which would ordinarily have devolved upon the Director. M. Villarceau was also intrusted, under M. Le Verrier's direction, with the preparation of the plans of the great Equatorial, erected in the west tower of the Paris Observatory.

The total eclipse of the Sun of July 18, 1860, was observed by M. Villarceau and other French astronomers at Moncayo, Spain, but the results of the observations were not published till 1868, when the detailed report, printed in the *Comptes Rendus*, was presented to the Académie des Sciences.

In 1857 M. Villarceau was appointed a member of the Bureau des Longitudes, and in 1867 a member of the Académie des

Sciences in the section of Geography and Navigation. He was an Officer of the Legion of Honour, and Chevalier of the Order of Charles III. of Spain, &c. He was elected an Associate of the Royal Astronomical Society on June 10, 1853.

During the important period when the reorganisation of the Paris Observatory became necessary after the death of M. Arago, in October 1853, M. Villarceau afforded great assistance to M. Le Verrier. During a fortnight's residence at the Observatory in 1854, the writer of this notice had many opportunities of observing the personal interest that he took in the ordinary work, which then had hardly settled down to the regular routine duties which M. Le Verrier was so anxious to introduce. But it did not require many days to perceive that M. Villarceau was more at home when employed on mathematical investigation than in active work at the telescope. But perhaps this was owing partly to the physical defect of deafness, to which he was even then subject. This infirmity increased in after years, and was the means of isolating him, in some measure, from the pleasure of association with his scientific colleagues.

No one would have considered from the appearance of M. Villarceau that his end was so near. Little more than two months before his death he was selected by the French Government, with Colonel Perrier and M. Faye, to represent them as delegates to the International Geodetic Congress held at Rome in October 1883. He afterwards visited Naples, and, notwithstanding his age, he ascended Vesuvius, and was taken to the edge of the crater. It is possible that the fatigues incidental to this Italian journey may have so weakened his constitution that his strength was not sufficient to overcome the severe illness which seized him about the middle of December, from the effects of which he succumbed after only a few days' suffering. He died on December 23, 1883, at his residence in the Boulevard Saint Michel, Paris, having nearly completed the seventy-first year of his age.

E. D.